Dynamic coupling between µCHP systems and buildings: sensibility analysis of the time resolution of the electrical demanddata and of µCHP modeling typology.

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Abstract:

The micro combined heat and power (µCHP) or micro cogeneration is a technology which produces simultaneously decentralized thermal and electrical (or mechanic) energy at low power (electrical power < 50 kW_{el}). This technology recovers the "fatal heat" losses considered as "heat waste" produced in thermodynamics or thermochemical cycles for mechanic energy production. This heat can be used to cover buildings heating and domestic hot water (DHW) needs. The µCHP matches the two goals of energetic system efficiency and greenhouse gas emission reduction by converting more efficiently the primary energy in final energy [1]. Besides, the integrationof these low thermal and electrical power systems within the energy consumption places lets to self-consume theproduced energy, to relieve the grid mainly during peak demand hours and to avoid grid losses.

A wood pellet steam engine and a gas (or biogas) Stirling engine µCHP devices have been tested at the laboratory of INSA Strasbourg in order to characterize their performances in steady and unsteady states. Two realistic and dynamic models based on these experimental investigations have been developed in previous works [2, 3] in order to predict their energy performances and their pollutant emissions. These models have been implemented in the TRNSYS's numerical environment where an optimization platform has been implemented. Thermal and electrical energy storage systems and energy management controller have been implemented in this platform which is used to optimize the couplingbetween buildings and this kind of innovative devices by considering energetic, economic and environmentalcriteria. [4]. Dynamic thermal simulations (DTS) only computes dynamic heating loads but the other most crucialparameters of the platform are the DHW load profiles and mainly the electrical load profiles in buildings whichneeds to be realistic, variable, suitable to the French context and with a low time step. Existing data basis areweakly suited to our platform because of their lack of precision (more than 5 min time step), their lack ofinformation (no information about the load profiles for each electrical appliance) or their non-relevance in theFrench context.

Stochastic and high resolution electrical demand and DHW demand generators have been created and are welladapted to the French context by using a "bottom-up" method aggregating the electrical load of each electricalappliance or specific DHW draw-off by a stochastic way [5].

Here we propose two kinds of sensibility analysis:

The first one deals with the time resolution of the electrical needs. This time resolution appears as crucial to catch the real variation of this quantity which is very variable and volatile. This “electrical” time step is not suitable with the “thermal” time step of thermal building energy simulations which involves usually hourly or semi hourly time steps. A big time step tends to smooth the peak of the electrical demand and artificially increase the self-consumption of the produced electricity. Besides, we propose a numerical repeatability analysis to show the dispersion about self-consumption ratios linked to different electrical demand data generated by the stochastic algorithm. The aim is to show the impact of the simulation time step and the reliability of the results linked to a data file. This study will help to obtain areliable and realistic finalresult.

The second analysis deals with the modeling typology. Precise data driven models have been developed by taking into account transient behavior and boundary conditions influence (cooling water mass flow and temperature). This sensibility analysis compares different modeling strategy (steady modeling, constant efficiency modeling and data driven unsteady modeling) and let to show the relevance to use such a model compared with the state of the art adopted modeling typology.

The sensitivity analysis will show the importance attached mainly to the time simulation,to the electrical demand data resolution and to the level of precision of µCHP models. About self-consumption ratios, simplified assumptions induce range differences of +10 to + 20% compared with a more detailed modeling.

Refernces :

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